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Climate Induced Changes in Biogenic Emissions: Global Chemical Effects

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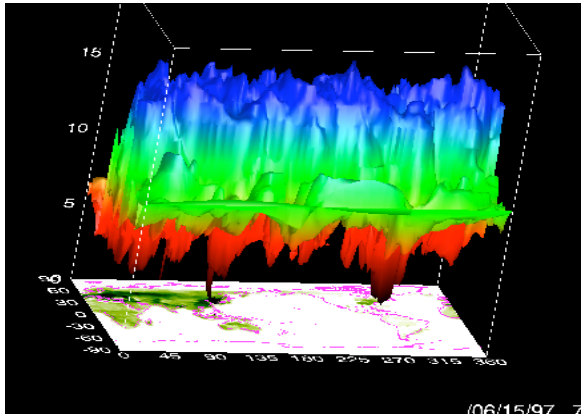
Climate Induced Changes in Biogenic Emissions: Global Chemical Effects



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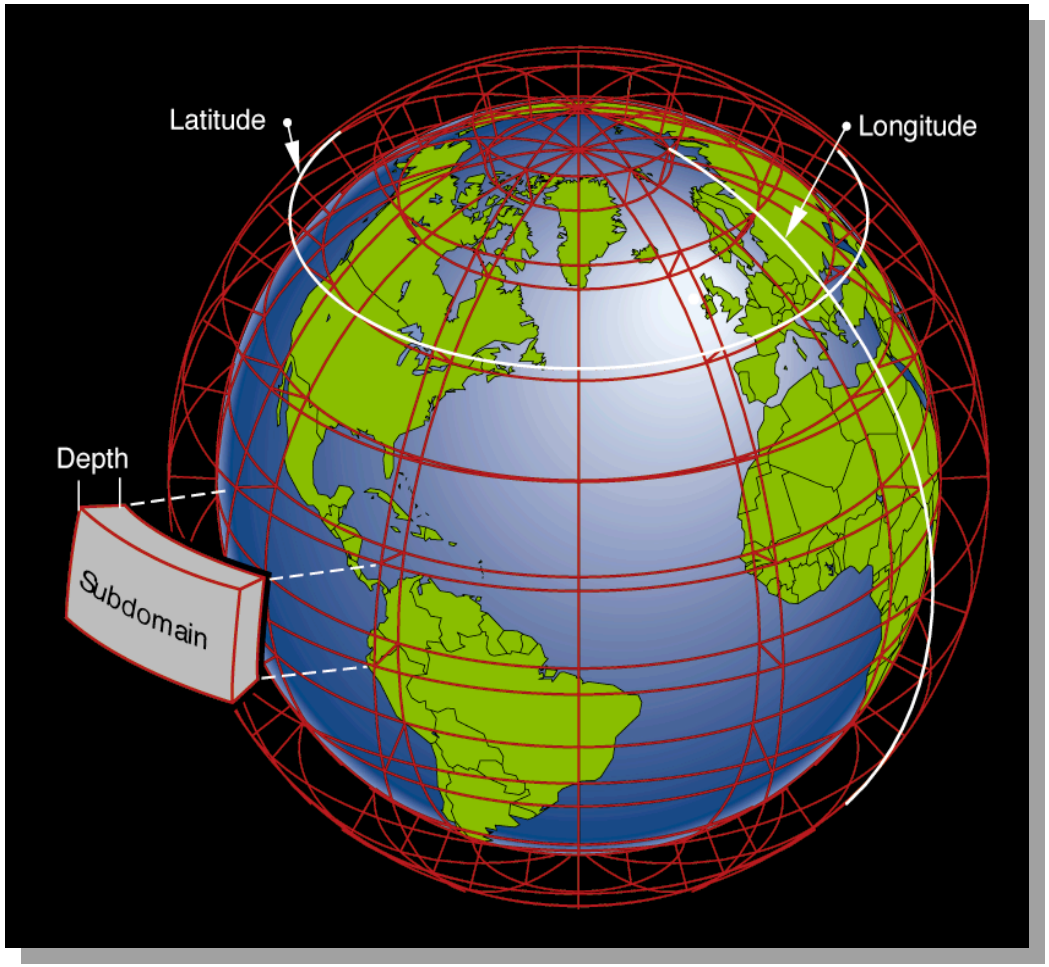
Use global, 3D model, IMPACT: How do 1 and 4K temp. increases affect biogenic emissions products?



- **Processes:** Chemistry, photolysis, advection, diffusion, wet & dry deposition
- **Species:** CO, CH_4, NO, NO_2, OH, O_3, C_5H_8, NMHCs, PAN, HNO_3, C_xH_y, BrO, ClO, (etc…to ~ 100)
- **Meteorology:**

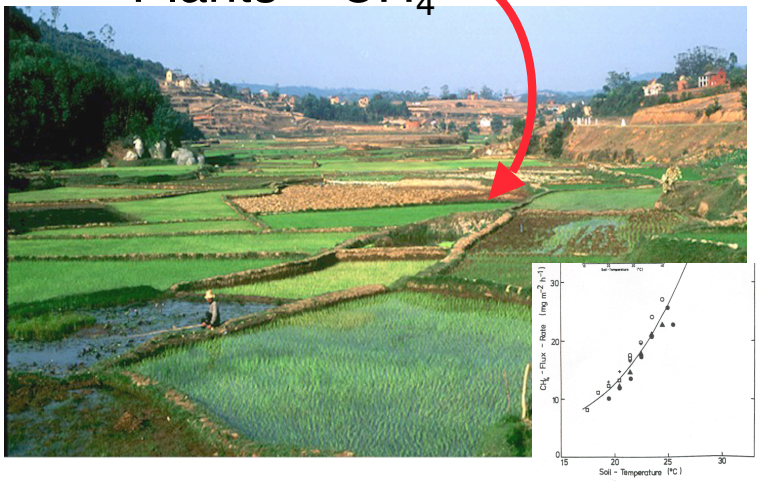
  MACCM3

  NASA/DAO (assimilated)
- **Resolution:**

  Met. Driven
  (2°x2.5°; 4°x5°; 1°x1°)

Emission rates of biogenic species (NO_x, CH_4, C_5H_8) are *nonlinear* in temperature:

Plants – CH_4



Plants, trees – isoprene (C_5H_8)

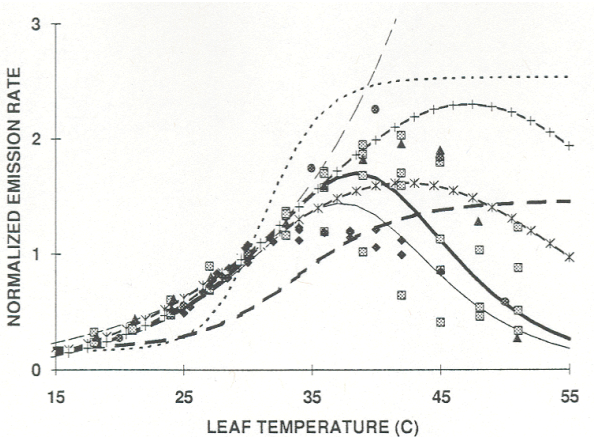
Lightning NO_x

Soils – NO_x

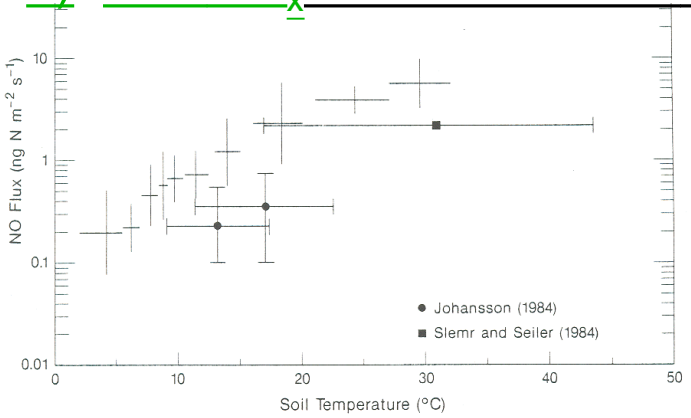
Affects many other species (e.g. O_3, OH, NO_x, HNO_3, PAN, …)

How will changes in four biogenic emissions affect atmospheric composition for T+1K, T+4K:

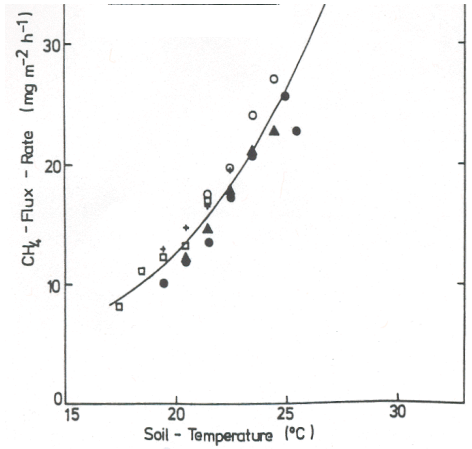
1) Isoprene - Guenther et al. 1993



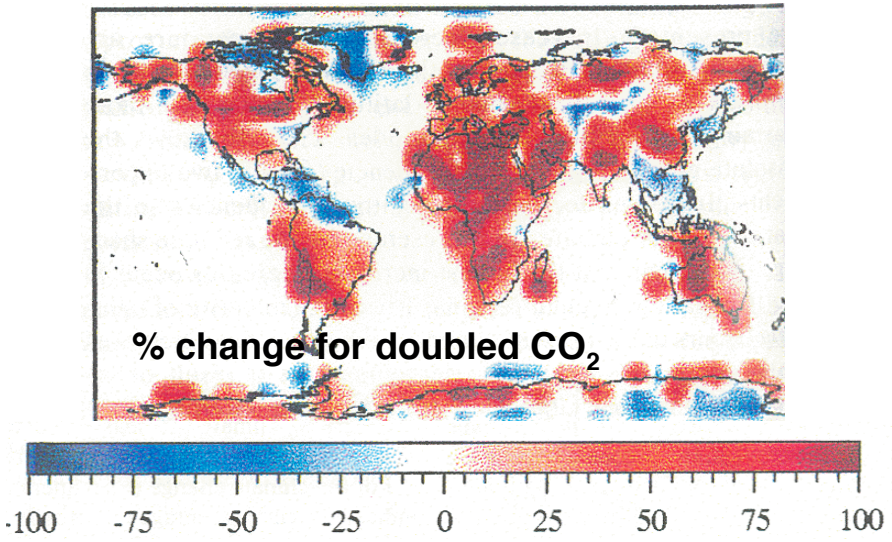
2) Soil NO_x - Williams et al. '92



3) Soil CH_4 – Schutz et al. 89



4) Lightning NO_x - Price & Rind '94



Temperature increases affect (1) biogenic emissions and (2) chemical reaction rates:

1) Biogenic emis. = fcn(T)

Soil $NO_x = A \cdot \exp\{0.071 \cdot T_{soil}\}$

2) Reaction rate = fcn(T)

A + B → products

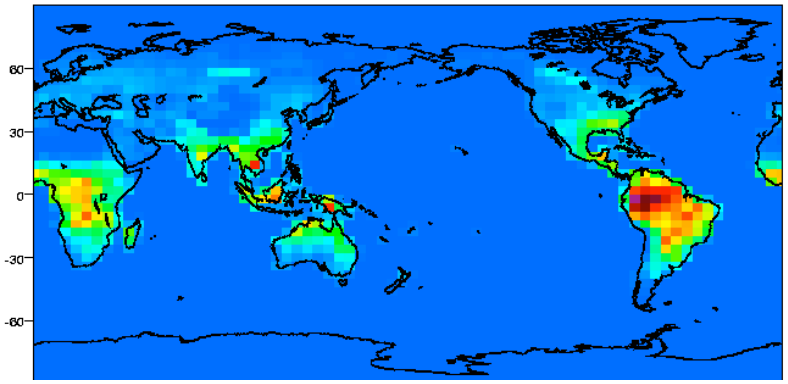
$k = A \cdot \exp(-E_a/T)$

PAN → $CH_3CO_3 + NO_2$

$k \propto A \cdot \exp(-14000/T)$

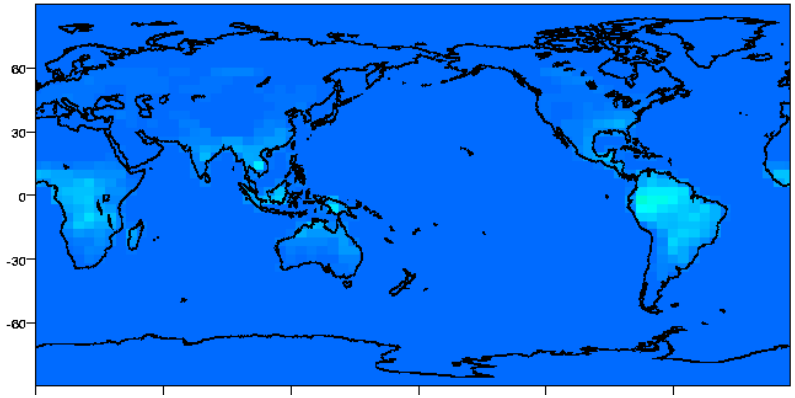
Scenario	Biogenic emissions	Reaction rates
Base	base	base
T + 1	↗	↗
T + 4K	↗	↗
T + 4K	↗	
T + 4K		↗

Isoprene emissions will increase as temperature ↑:

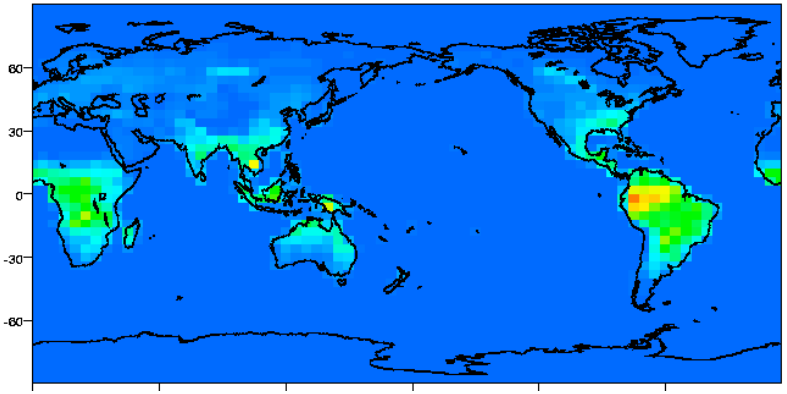


Present day (Base case)
Isoprene source: #/cm^2-s

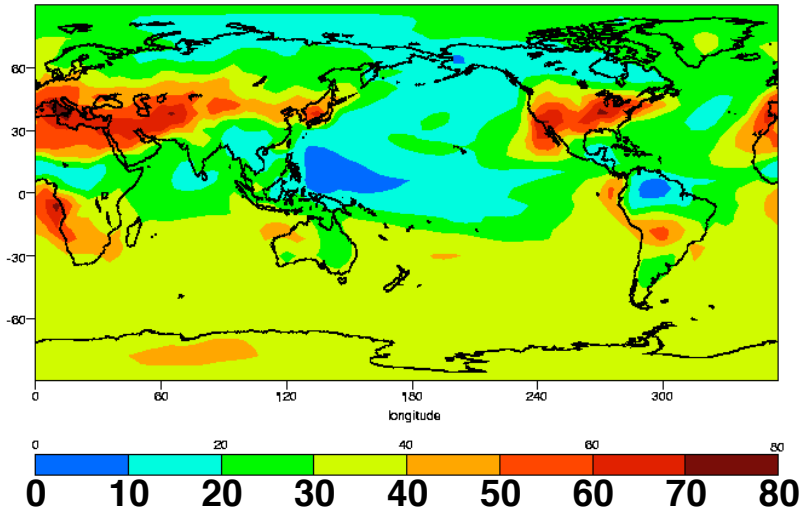
□ isoprene for 1K (13%)



□ isoprene for 4K (58%)



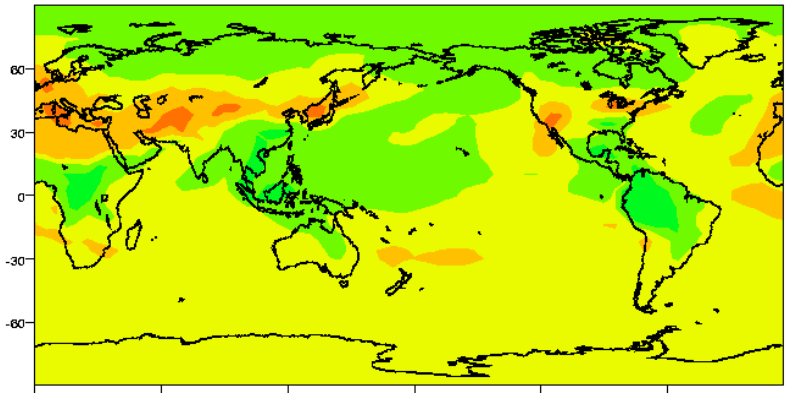
July Surface O_3 changes more for 4K than 1K:



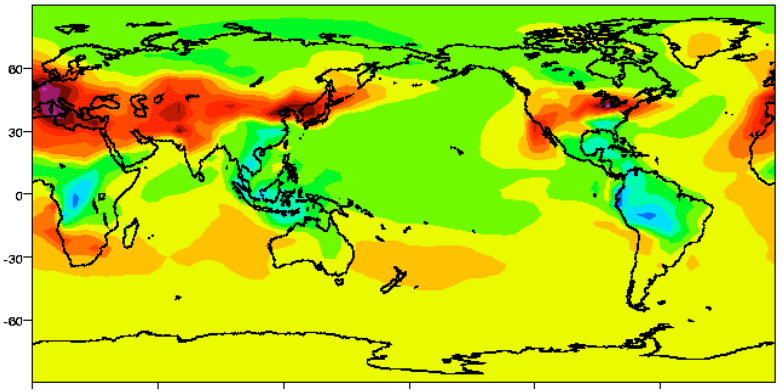
Surface O_3, ppbv

Base case

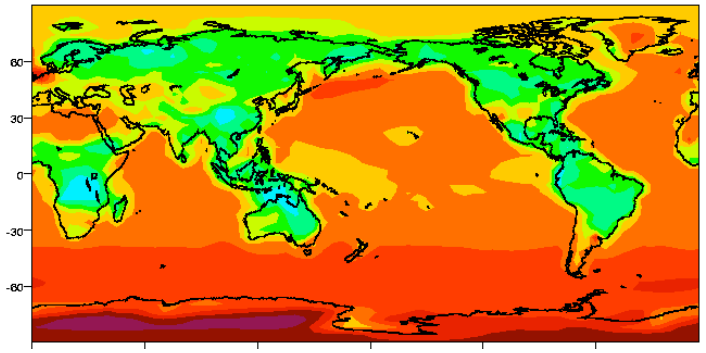
ΔO_3 for 1K case



ΔO_3 for 4K case



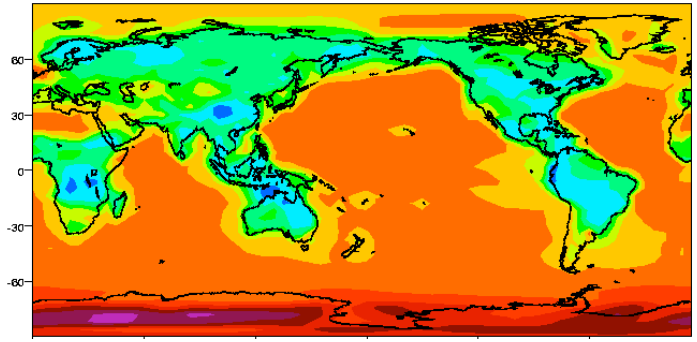
July surface OH for 4K case – Net decrease (land) mainly due to increased emissions



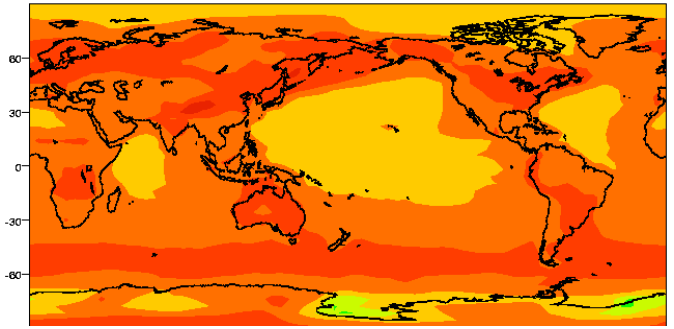
Surface OH in %

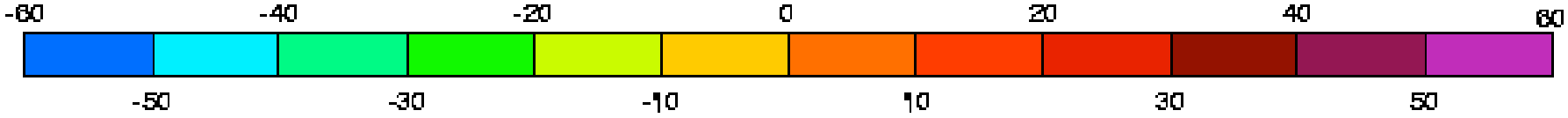
T + 4K

OH – emissions only

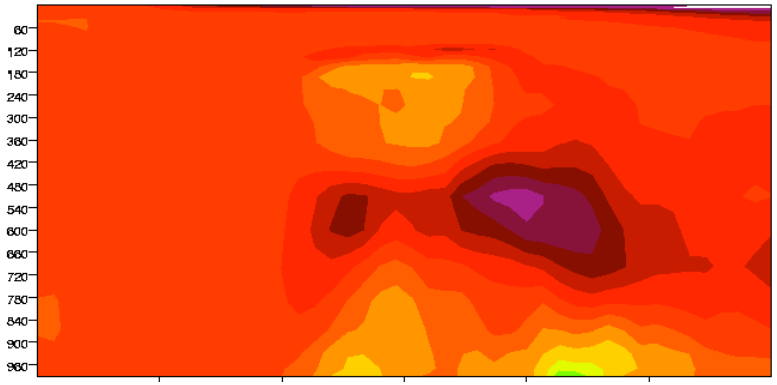


OH - rxn rates only





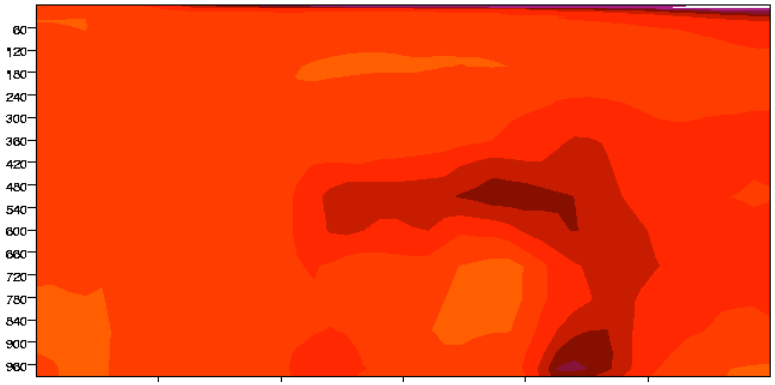
July zonal OH for T + 4K: Increase at 400-700mb Decrease at surface, Decrease above 400mb



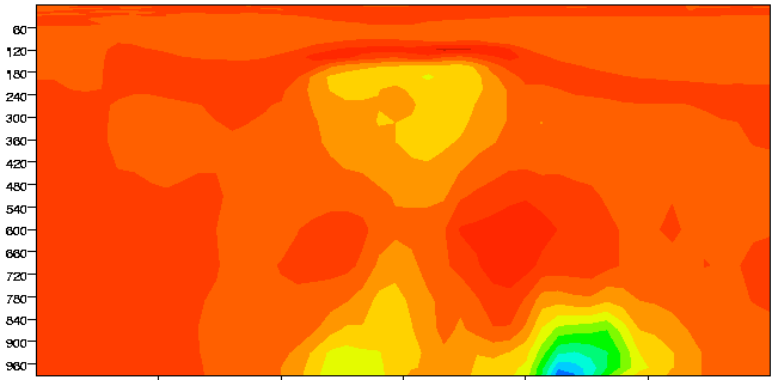
ΔOH, #/cm^3 x 10^{-5}

T + 4K

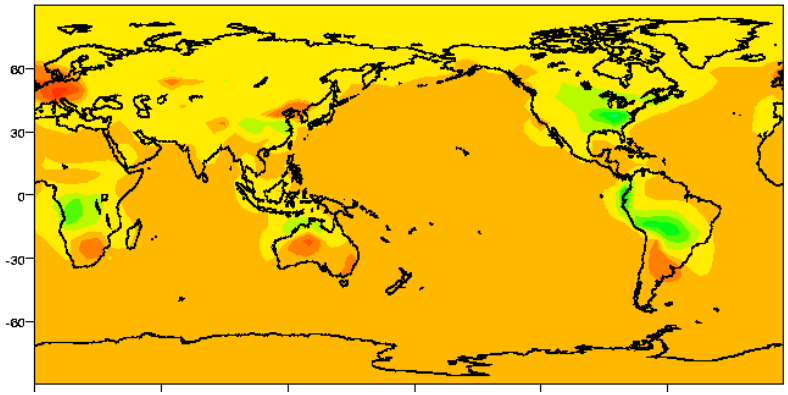
Δ OH – rxn rates only



ΔOH - emissions only



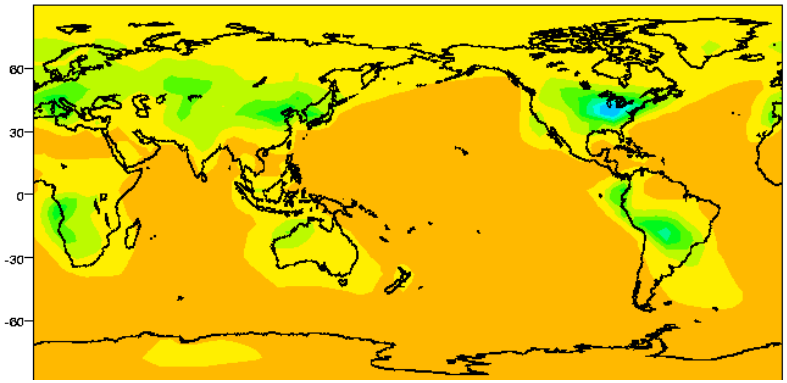
July surface PAN changes for 4K case - Net decrease due to reaction rates changing



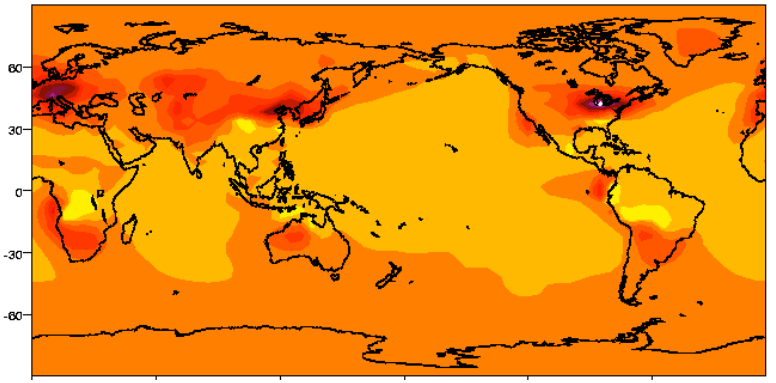
Surface PAN, pptv

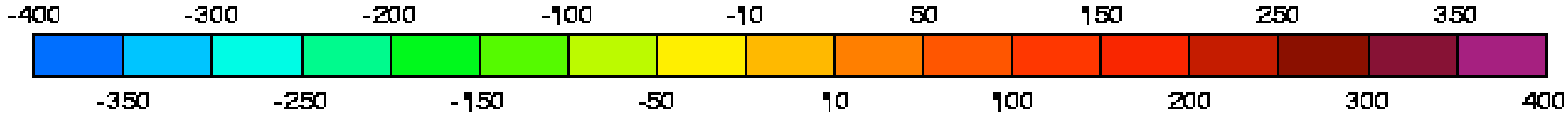
T + 4K

PAN – rxn rates only

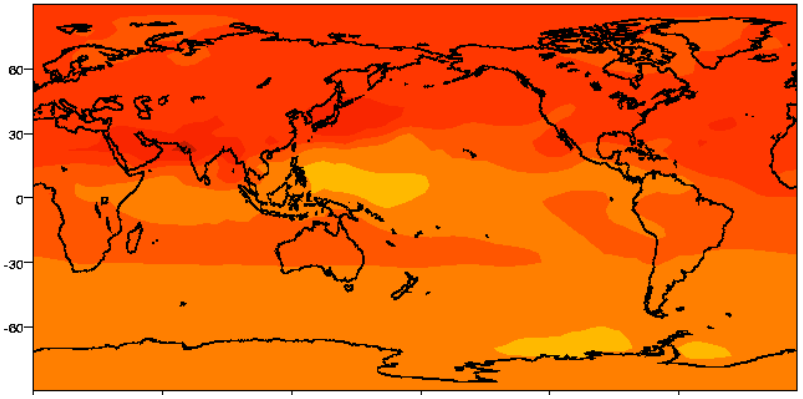


PAN – emissions only





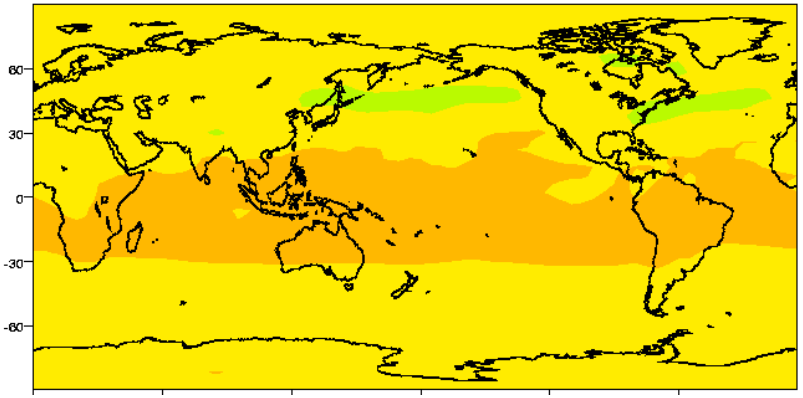
July 300mb PAN changes for 4K case - Net increase due to emission rates changing



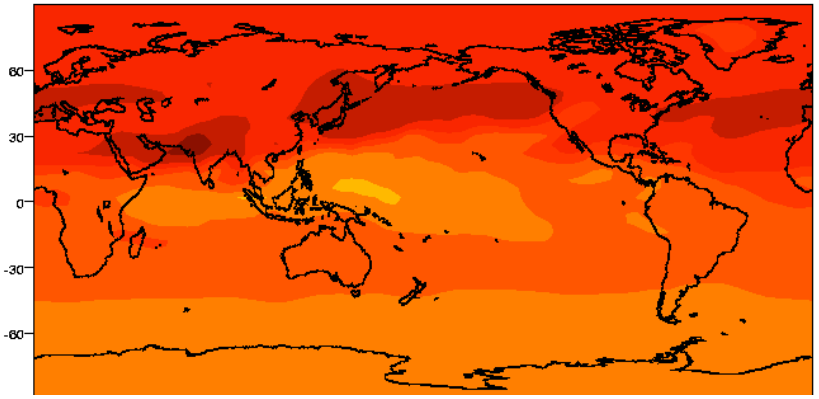
PAN at 300mb, pptv

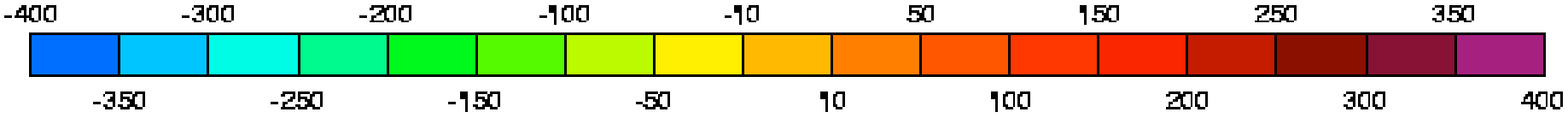
T + 4K

PAN – rxn rates only



PAN – emissions only





IMPACT model temperature increase of 1 - 4K affects (1) Biogenic emissions (C_5H_8, NO_x, CH_4) and (2) Reaction rates

- July Surface O_3 changes:

  -4 to 10 ppbv for 4K

  -2 to 4 ppbv for 1K

- July OH changes for 4K:

  Decreases surface (~50%), 200 – 400 mb

  Increases 400 – 700 mb

- PAN depends on altitude for 4K

  Surface: Net decrease

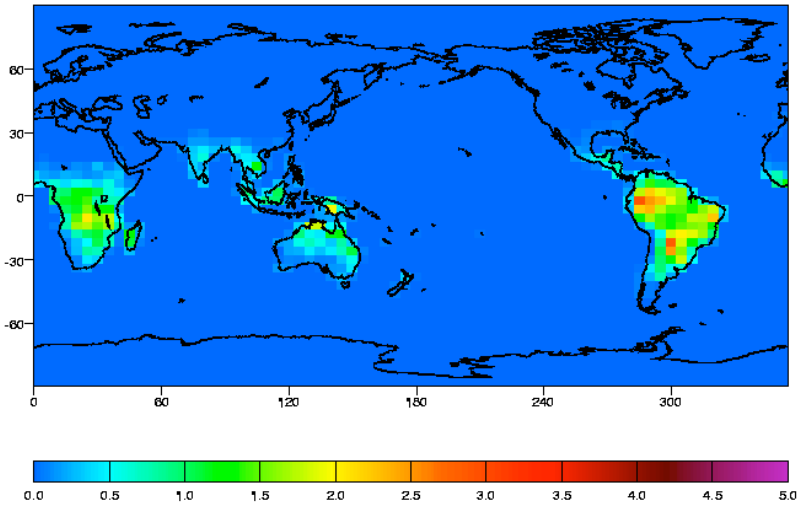
  300 mb: Net increase

- Future work includes different temperature representation (spatial, temporal)

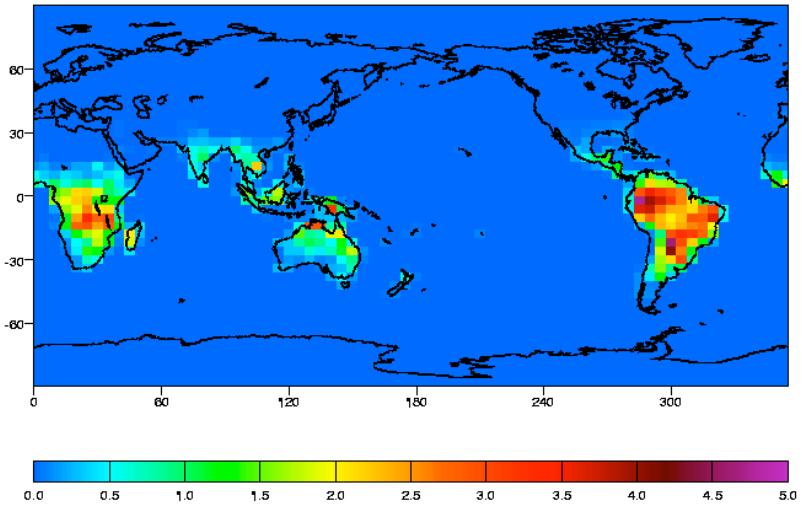
Backup Slides follow . . .

Isoprene emissions will increase as temp ↑

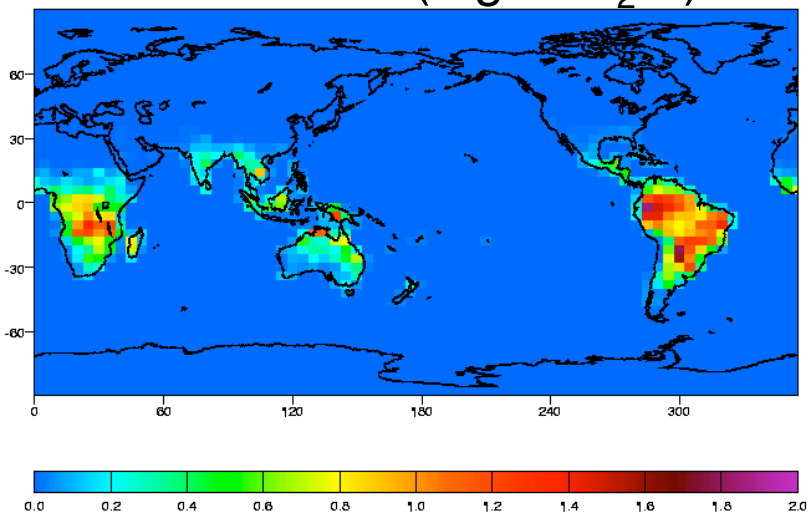
Base Case (Jan)



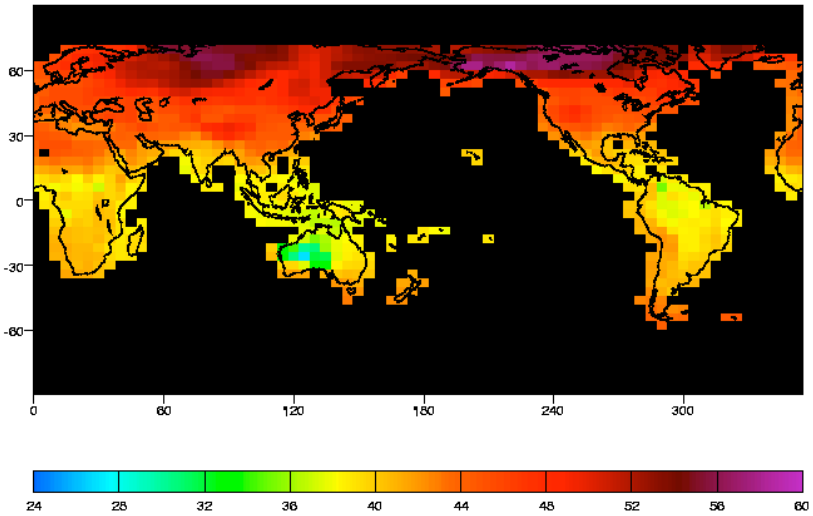
Temp increase 4K (Jan)



Total increase (mg C/m_2-h)

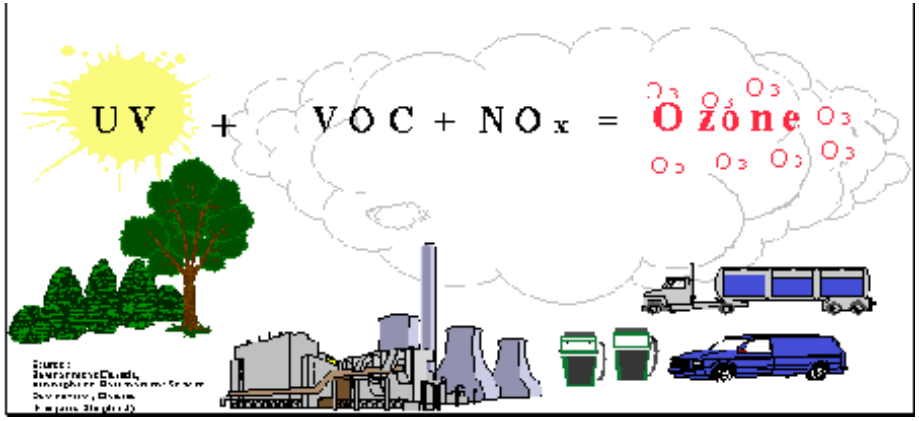


% increase

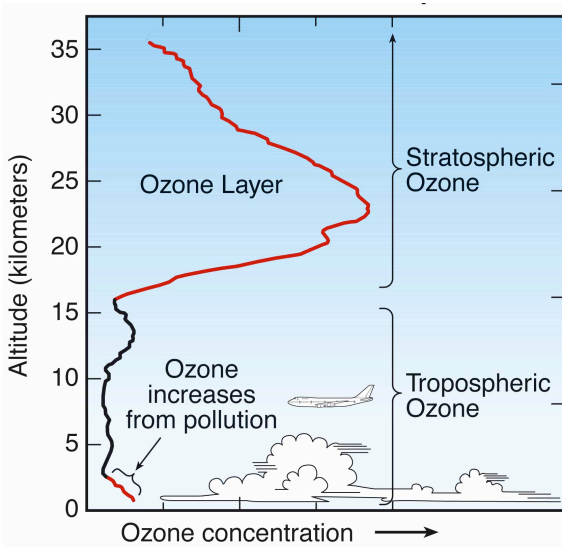


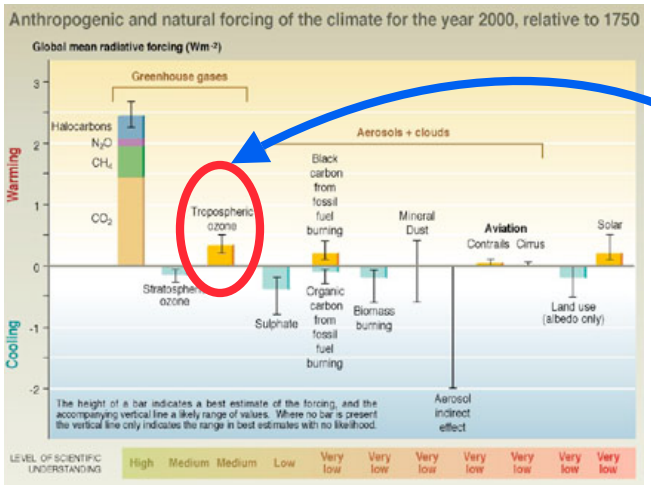
A key species is tropospheric ozone. It has two main "sources".

(1) *Tropospheric in-situ photochemistry*



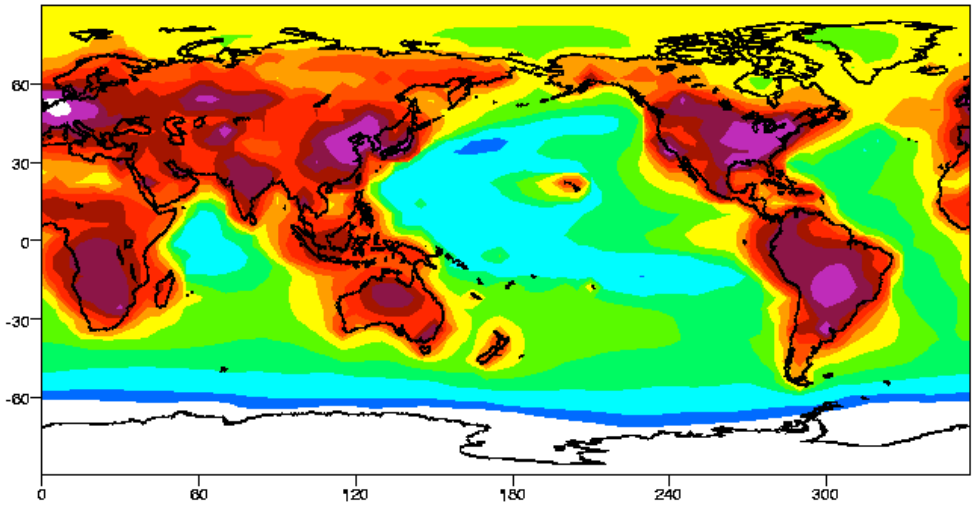
(2) *Transport from stratosphere (Huge reservoir)*



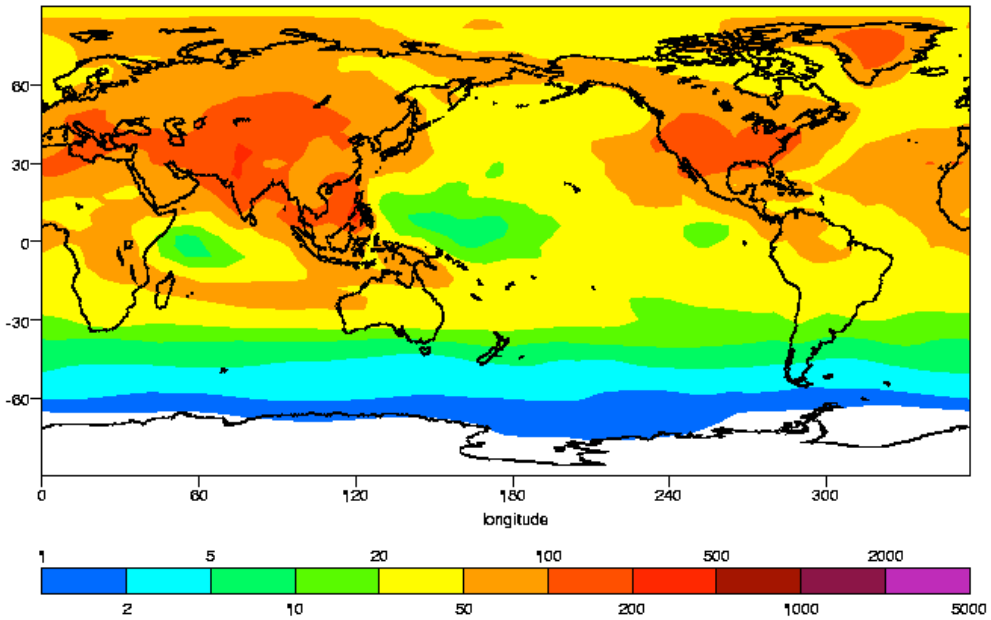


It can act as a greenhouse gas.

July NO_x for base case:

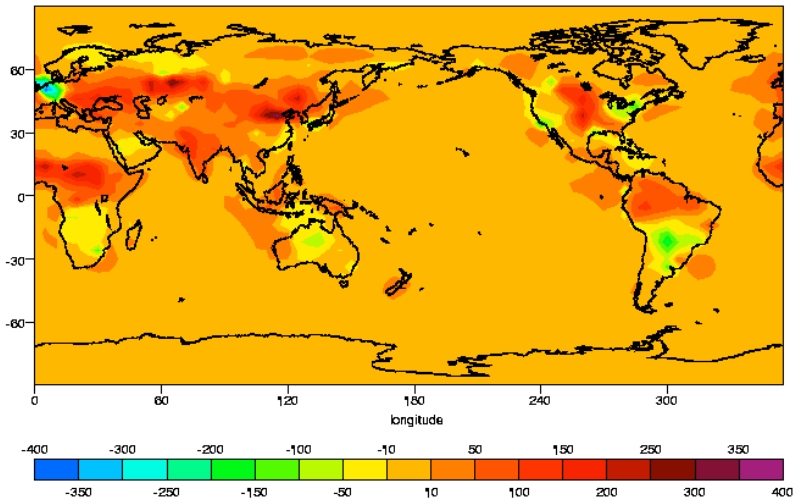


Surface NO_x, pptv
Base case



NO_x at 300 mb, pptv
Base case

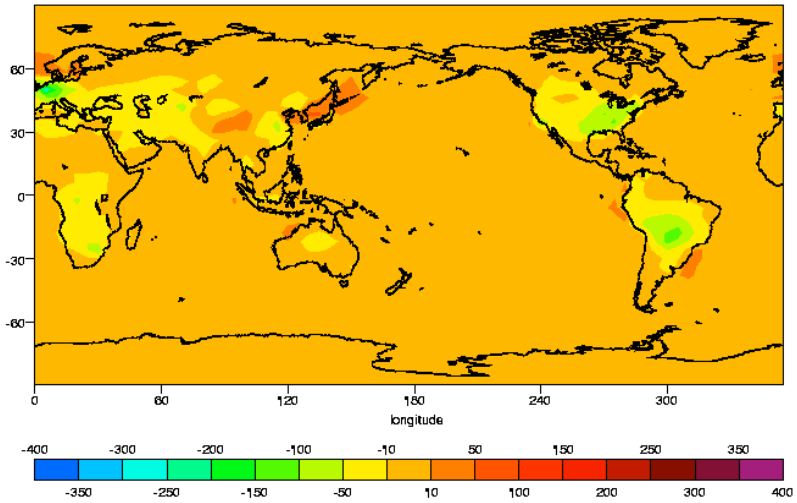
July surface NO_x changes for 4K case



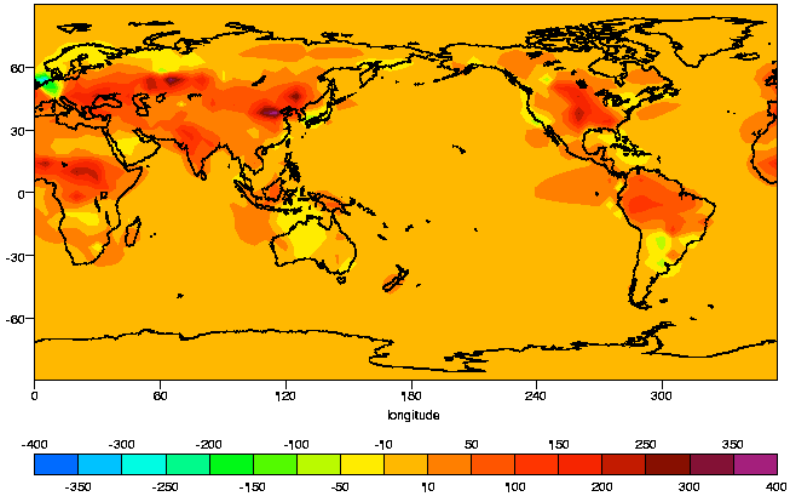
Surface NO_x, pptv

T + 4K

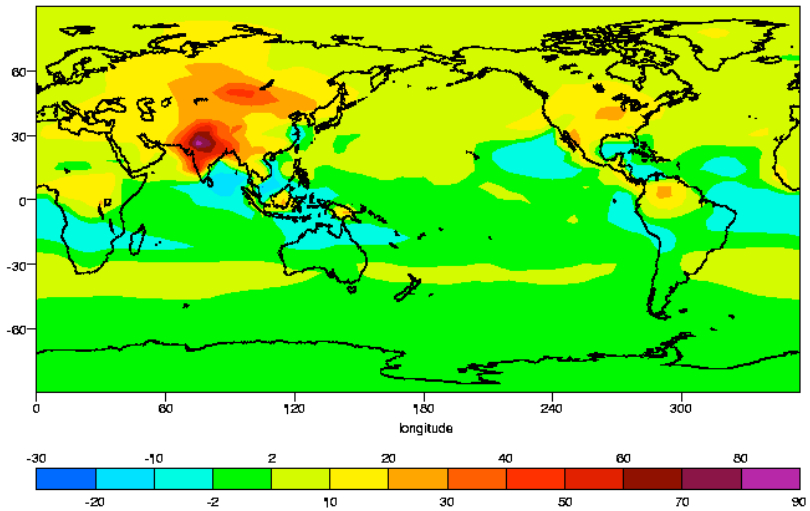
NO_x – rxn rates only



NO_x – emissions only



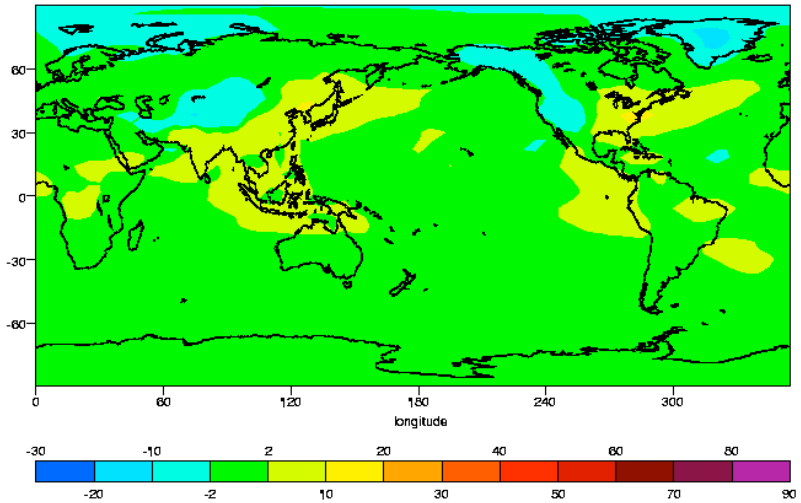
July NO_x changes at 300 mb for 4K case



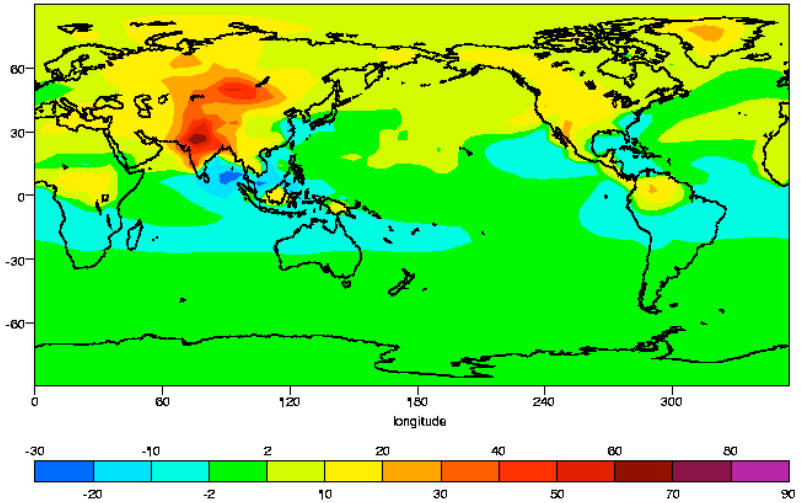
ΔNO_x at 300 mb, pptv

T + 4K

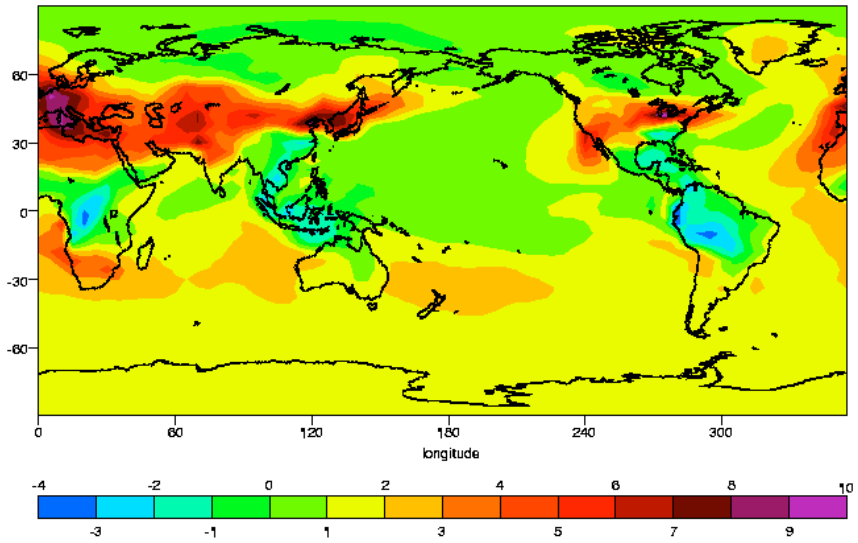
Δ NO_x – rxn rates only



ΔNO_x – emissions only

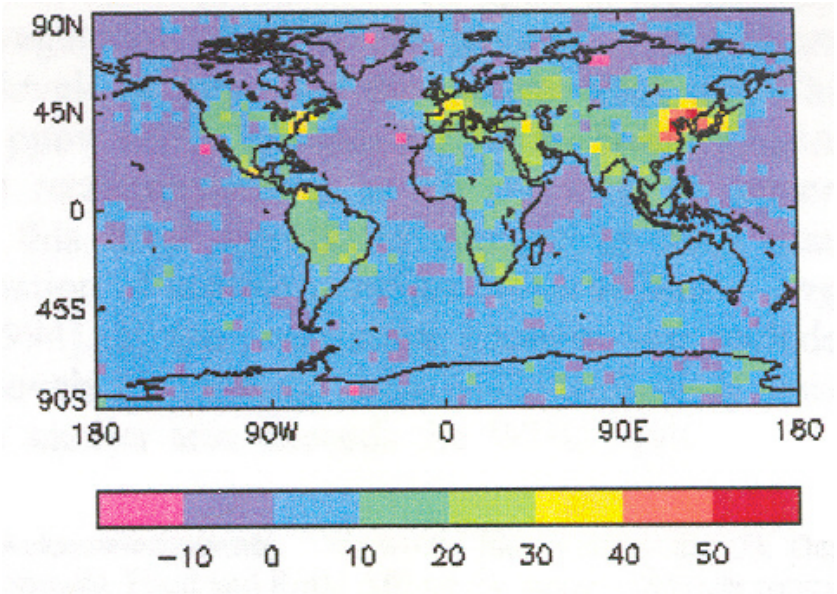


Our surface O_3 changes are less than Sanderson et al. They also increased VOCs and NO_x (anthropogenic)



ΔO_3 at surf, this work

T + 4K



ΔO_3 at surf, this work

Sanderson et al., 2003

(Fig. 2, 2090-1990,

Fixed vegetation)

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